

Technical Application Bulletin For All VAP's TAB-VAP-102

Date: March, 2002
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Objective:

To determine the molecular weight of a gas mixture so that density may be calculated

Gas ---Air The following example is for air but any other mixture may be substituted

Molecular Weight Calculation of Mixtures

Nitrogen, N₂

$$mF_1 := .7806 \quad M_1 := 2 \cdot 14.0067$$

Oxygen, O₂

$$mF_2 := .21 \quad M_2 := 2 \cdot 15.9994$$

Argon, Ar

$$mF_3 := .0094 \quad M_3 := 39.948$$

Gas Component 4

$$mF_4 := 0 \quad M_4 := 0$$

Air mol or volume fraction from [CRC Handbook of Chemistry and Physics](#)

$$mF_1 + mF_2 + mF_3 + mF_4 = 1$$

$$M_{wt} := \frac{mF_1 \cdot M_1 + mF_2 \cdot M_2 + mF_3 \cdot M_3 + mF_4 \cdot M_4}{mF_1 + mF_2 + mF_3 + mF_4} \quad M_{wt} = 28.963 \quad \text{molecular weight calculation for standard air}$$

Density Calculations

$$R_{\text{universal_gas_constant}} := 8314.32 \cdot \frac{\text{m} \cdot \text{N}}{\text{kg} \cdot \text{K}}$$

$$\text{in_wc} := \frac{\text{psi}}{27.68}$$

EI definition of in_wc

$$p := 101325 \cdot \text{Pa} \quad p = 14.696 \text{ psi} \quad p = 760 \text{ torr} \quad p = 406.784 \text{ in_wc} \quad (760 \text{ mm_Hg Std Atm})$$

$$T_{\text{gas}} := (15 + 273.15) \cdot \text{K}$$

[(15°C Std Atm)--note this is dry air--ASHRAE Std is saturated at 60°F which is about the same as 69°F dry ~ .075 lb/ft³]

$$\rho_{\text{gas}} := \frac{M_{wt} \cdot p}{R_{\text{universal_gas_constant}} \cdot T_{\text{gas}}}$$

equation of state is used to calculate density of a gas if molecular weight is known

$$\rho_{\text{gas}} = 0.076469 \frac{\text{lb}}{\text{ft}^3} \quad \rho_{\text{gas}} = 1.225 \frac{\text{kg}}{\text{m}^3}$$

this fits definition of international standard atmosphere [Ower and Pankhurst](#) at indicated conditions

To solve for density at conditions other than the given conditions, then calculate by:

$$\text{Unit_Constant} := \frac{\frac{\rho_{\text{gas}}}{\frac{\text{lb}}{\text{ft}^3}} \cdot \frac{T_{\text{gas}}}{\text{R}}}{\frac{p}{\text{in_wc}}} \quad \text{Unit_Constant} = 0.0975$$

This will be for the above calculated gas only

$$T_{\text{air}} := 69 \quad P_{\text{static}} := 406.78 \quad \text{density} := \frac{\text{Unit_Constant} \cdot P_{\text{static}}}{T_{\text{air}} + 459.67} \quad \text{density} = 0.07502$$

Restate the temperature to see if the calculation results in the standard calculation as ASHRAE as stated above-- this shows both method and calculation.

RECOMMENDATIONS: Use the **DPS** reciever to calculate the density from a given molecular weight gas. Use of the **DPU** reciever will require calculation of both the molecular weight and density and entering this value into the **DPU**

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